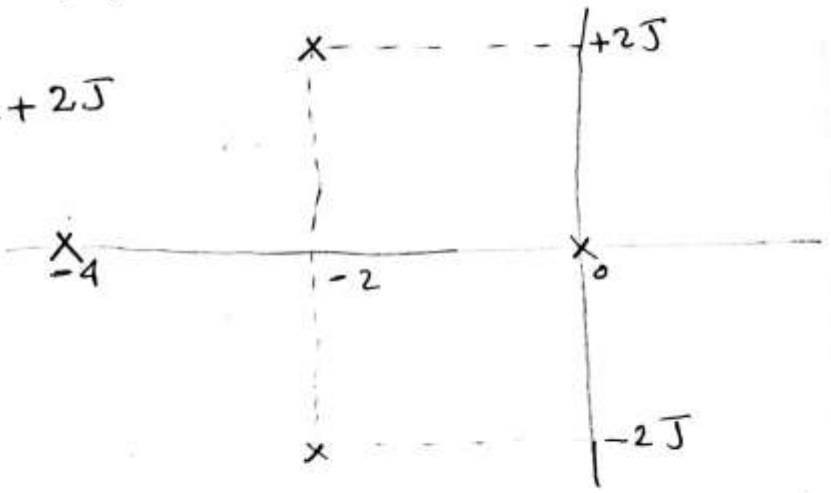
# Sec 3 : [redacted] Control

## Quiz

$$GH(s) = \frac{K}{s(s+4)(s^2+4s+8)}$$

Poles → $0, -4, -2-2j, -2+2j$

Zero → $\phi$




## Real Part

$0 \longrightarrow -4$

## Asymptotes

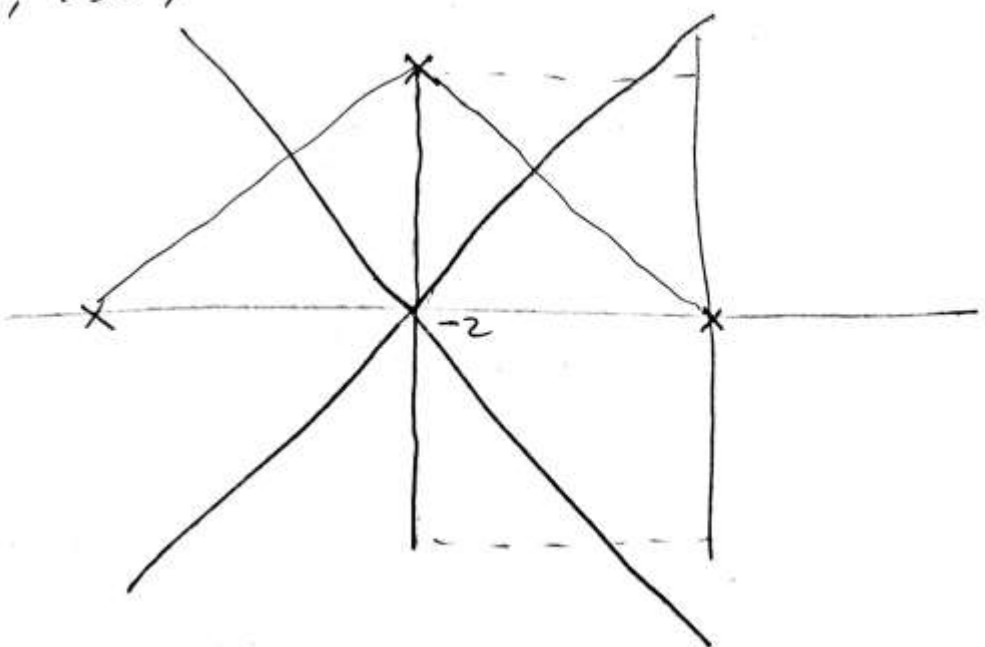
number s $4-0=4$

$$C_A s \frac{(-4+0-2-2j-2+2j)-0}{4-0} \quad s-2$$

$\theta = 45, -45, 135, -135$

$$D = 180 - \phi_p - \phi_z$$

$$= 180 - (90 + \tan^{-1}(1) + 135) \quad s-$$



* For the system has O.L.T.F = $G H(s)$

Prove that $K = \frac{\pi P_i}{\pi Z_i}$

Sol

$O.L.T.F = GH(s)$

$C.L.T.F = \frac{KGH(s)}{1+KGH(s)}$

c/c eqn $= 1 + GH(s) = 0$

$KGH(s) = -1 = 1 \angle 180$

$GH(s)$ : Function in Complex Variable

$S = \sigma + j\omega$

$\| GH(s) \| = 1$

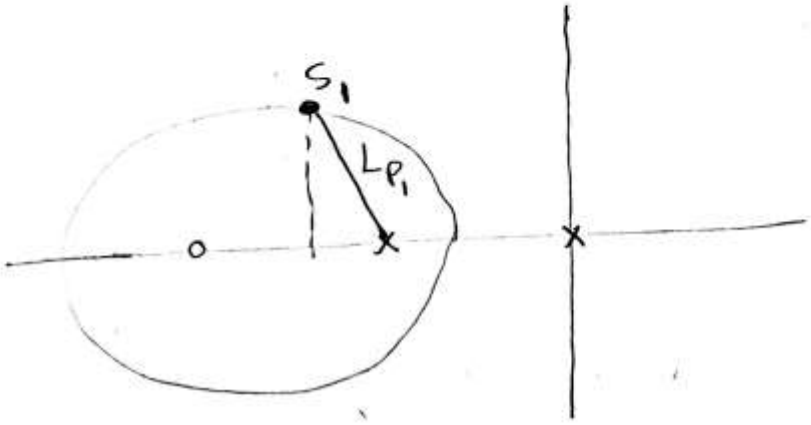
$\angle KGH(s) = 180$

$K = \frac{1}{\| GH(s) \|}$

$GH(s) = \frac{(S+Z)(S+Z_2)\cdots}{(S+P_1)(S+P_2)\cdots}$

$$||GH(s)|| = \frac{|s+z_1||s+z_2|\cdots}{|s+p_1||s+p_2|\cdots}\Bigg|_{s=s_1}$$

$s_1 = \sigma_{s_1} + j\omega_{s_1}$




hint $a+jb$

$\Rightarrow \sqrt{a^2+b^2}$

$$||GH(s)|| = \frac{[\sigma + j\omega + z_1]\cdots}{[\sigma + j\omega + p_1]\cdots}$$

$z_1 = \sigma_{z_1} + j\omega_{z_1}$

$$||GH(s)|| = \frac{\left[\sqrt{Re_{z_1}^2 + Img_{z_1}^2}\right]\cdots}{\left[\sqrt{Re_{p_1}^2 + Img_{p_1}^2}\right]\cdots}$$

$$= \frac{L_{z_1} \cdot L_{z_2} \cdots}{L_{p_1} \cdot L_{p_2} \cdots}$$

where

$L_{z_1}$ → length of line between open loop zero and considered closed loop pole($s_1$)

$$\therefore GH(s) = \frac{\prod L_{z_i}}{\prod L_{p_i}}$$

$$\therefore K = \frac{\prod L_{p_i}}{\prod L_{z_i}}$$

* Departure Angle from complex poles

$$\theta_d = 180 - \phi_p + \phi_z$$

* Arrival Angle to complex poles.

$$\theta_A = 180 - \phi_z + \phi_p$$

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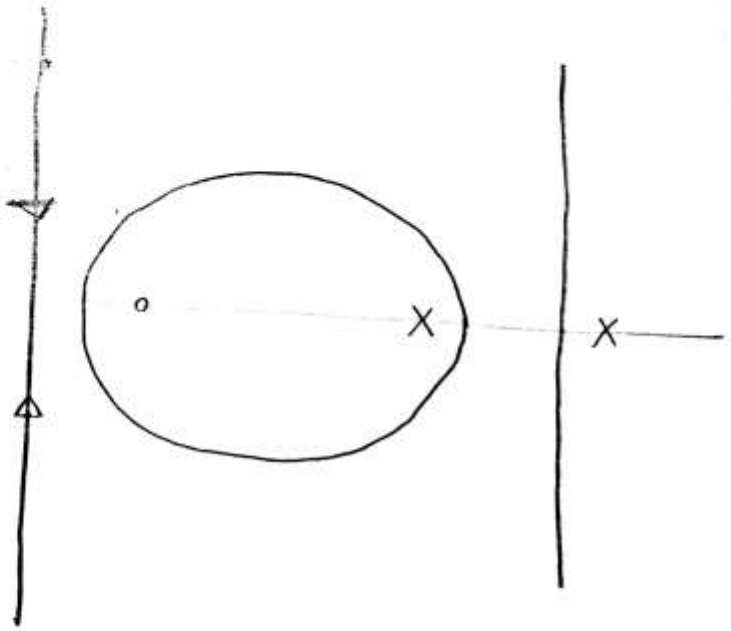
توضيح خطأ في المسألة من السكشن السابق.

$$GH(s) = \frac{K(s+2)(s+4)}{s(s+1)}$$



الغلط كان في مكان
ال (breaking point)

Breaking out ✓

Breaking in ✗ ← الغلط

Correction

root locus Breaking in mores (between zero) little to right not the left

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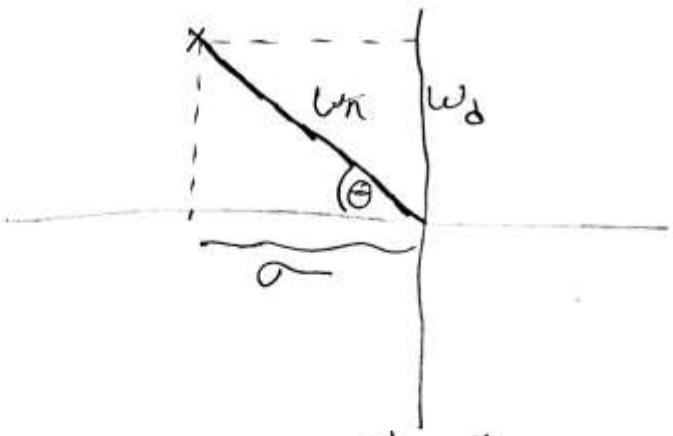
C.L. Poles




$$\omega_d = \omega_n \sqrt{1-\zeta}$$

$$\sigma = \zeta \omega_n$$

$$\sqrt{\omega_d^2 + \sigma^2} = \omega_n$$

$$\theta = \cos^{-1} \zeta$$

→ System speed depends on $\sigma$.

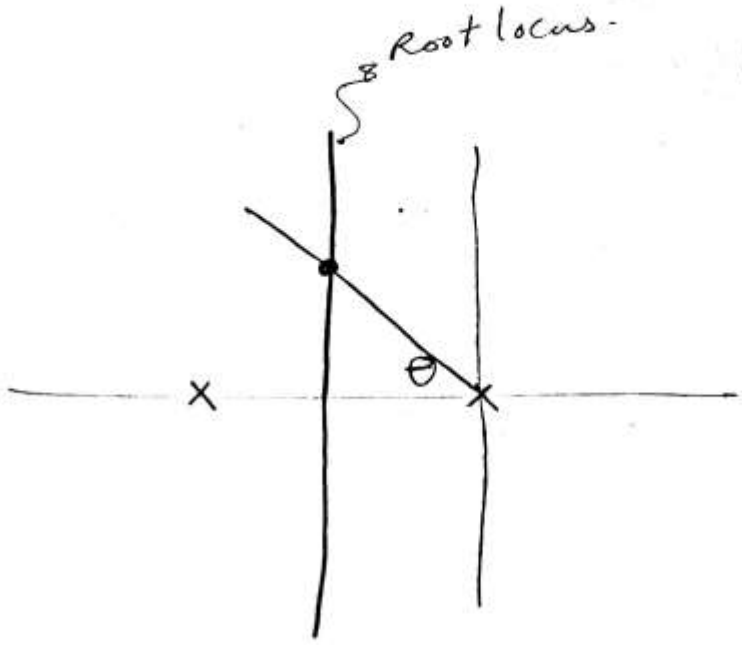
time Constant

$\tau$ ⇨ time for system to reach 63% of the response

$$\tau = \frac{1}{\sigma}$$

Settling time $t_{ss} \; 4\tau = \frac{4}{\sigma}$

## Root locus




```
num = [1  6  16];
den = [1  4  8  0];
G = tf(num,den);
rlocus(G)
sisotool
```